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Decision-Making Modeling and Evaluation of E-Trust in B2C E-Commerce with Using Colored Petri Nets

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Abstract

Since doing any transaction in online environment requires mutual trust, thus, according to an electronic-environment that lack face-to-face meeting of both parties and the possibility of visible and physical touch of what is being traded, the security and trust will lead to doing transaction with the acceptance of risk. This issue is the major challenge in gaining trust in e-commerce. In this paper, decision-making in e-commerce was modeled and then the level of trust in e-commerce was assessed using CP-Nets by identifying, introducing and evaluating the variables affecting decision-making. The results of the study indicate that corporate factors and business model have the greatest impact on customers' decision-making to trust or distrust in e-commerce for fulfilment of every e-transactions.

Keywords: E-Trust, e-commerce, decision-making, modeling, evaluation, CP-Nets (Colored Petri nets);
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1. Introduction

Due to the characteristics of e-commerce environment, i.e. lack of face-to-face meeting between parties and lack of visibility of the product or service in an online transaction, it is an environment with a high risk for parties and each side has its own concerns for the online perception of this interaction [1]. Given the importance of the factor "trust" and its relationship with concepts of risk,

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security, reputation, loyalty and satisfaction in electronic trading and the inherent character of the word "trust" that has various dimensions and structures under the influence of the context under study, several studies have been conducted in recent years that each has dealt with the issue with a particular perspective, but risk is often considered as the core of trust in electronic transactions. With regard to risk, trust is a score that shows positive attitude toward the good behavior and confidence of the trustee for trustor in a risky exchange situation. In traditional environment, face-to-face meeting, negotiation and bargaining at the site of interaction along with observing or touching the product or service led to the trust to confirm the decision of the parties to make the transaction. However, the concept of the construct trust is replaced with online trust or e-trust in the electronic environment, which is due to the lack of some of the interactive factors interact in a traditional setting. In the electronic environment, the term e-trust implies that in an interactive system or relationship, one party, as trustor, is willing to accept vulnerability to another party, internet trustee, based on positive expectations about the future behavior of internet trustee. According to Ayas' definition, e-trust is consumer's willingness to accept vulnerability to an online seller based on positive expectations about the future behavior of the seller [2]. Trust is a dimensional concepts and complex social phenomenon. The concepts developed in social sciences provide an important foundation for trust formalization. A large scale of research has contributed to the conceptualization of trust [3]. Trust is an emotional form of thoughts and it is not clear whether integrity , good will and sincerity can be segregated since they are related. Many researchers have explained trust as an act of faith, confidence and reliance on something that is expected to behave or deliver as promised [4]. Trust is a multi-dimensional word playing an important role in many human knowledge fields including economy, history, psychology and computer history and science. Trust-based behavior happens when one is doubtful about selecting a path and his/her selection may have a good or bad consequence [5]. Assume that the loss induced by the bad consequence is more severe than the advantage of the good one. In fact, that person has either made a trust-based selection or followed a trustless procedure. In his/her opinion, the existence of trust implies some degrees of uncertainties in the result [6]. A number of studies conducted in the field of trust in e-commerce will be discussed in the next sections. In [7], remote calls and reps to help estimate the degree of confidence of the other party have been suggested to deal with this risk in P2P exchange. In this method, three main parameters of customer feedback from other customers, the total number of transactions a customer has done, and the credibility of the source of feedback from customer have been used as the main factor in determining decision model about the level of trust in P2P business model. Like [7], [8] has also used the repetition pattern of transactions to determine the level of customer confidence. This means that the more transactions done by the customer, the customer will trust and do transactions better so that lower risk threatens him.

In [9], the security aspects of electronic exchanges and their impact on the trust of parties have been discussed. In this method, a model has been proposed for secure identification of the user using encryption algorithms, authentication, and secure online communication. The model has been tested on 179 customers and the obtained results are significant. In [10], the integration of customer confidence with technology acceptance model is utilized to model the trust of customers. This model addresses the direct relationship between trust in using up-to-date technologies such as internet mobile and web pages of online financial transactions with trust in e-commerce. Finally, the hypothesis was tested on 59 different categories of technology that 76% of them emphasized the validity of the proposed model.

In [11], a model for trust in B2C for the bank transactions is proposed. In this method, the influence of large companies in these types of transactions is examined and then, the difference between these types of transactions and the model of customer trust in this type of transactions, compared to P2P

transactions, is discussed. The proposed model is built based on the two principles of security and privacy. In other words, the proposed model considers that customer trust in the business model has originated from confidence in the security of the bank and observation of customer's privacy by bank. In [12], the distance between customers full trust in transactions and financial communications is pointed out as a major challenge in trust in electronic business. Then, solving security and privacy problems by banks is proposed as the main solution to create trust in electronic business. To this end, different strategies for creating confidence are presented in this model, the majority of which emphasize enhancing the security and privacy of users.
In [13], customer trust in electronic transactions is proposed as an agent to keep and develop the e-commerce process. In this method, the effect of trust factors such as seller's reputation, customers' confidence in transaction security and privacy has been investigated. Studies conducted using this method has led to the introduction of two parameters of customer's trust in protecting personal privacy and customer's trust in the security of electronic transactions. In [14], a system for deciding about trust in electronic business model is provided. In this method, the following three basic questions are answered:
1)- Are trust and risk important in e-commerce?
2)- How was the experience of risk and trust in these transactions?
3)- How do risk and trust affect user's decision-making in e-commerce and the Internet?
A theoretical framework for decision-making system about trust in e-commerce is proposed and then, tested using data gathered from customers' behaviors to answer these three questions in this study. The results show that the proposed model is based on the behavior of the majority of customers.
The proposed solution and framework of this study is similar to [14], i.e. a decision-making model to trust in e-business is presented and then tested using data collected from users' behavior.
The paper will be continued as follows: petri nets and colored petri nets are introduced and then, the proposed algorithm is described. Finally, the proposed model is evaluated according to customer behavior data.

2. The proposed approach

Here, Petri nets and colored Petri nets are first introduced and then, the model designed using colored petri nets is presented.
Petri Nets illustrate a continuous effort to establish , develop concepts, theories and tools to aid in design and analysis of concurrent systems. Petri net theory allows a system to be modeled via the net and, in fact, it is a mathematical representation of that system. The dynamic behavior and structure of the system modeled by Petri net analysis provides useful information. The information can be used to evaluate and guess improvements or changes in the system.
Many scientists have used Petri Nets to analyze and study systems in different scopes of science and engineering such as numerical analysis, control systems, artificial intelligence, parallel processing system and communication protocols modelling and verification by Diaz [15]. And then, others introduced the were improved version its called CP-Nets. CP-nets or CPNs or Coloured Petri Nets or Colored Petri Nets were improved as an extension to Petri Nets [16]. CP-nets prepare a framework for making , validation and verification of various kinds of systems [17]. They have been considered as a language to model and validate systems such as communication protocols, information systems , software and engineering systems [18].

2.1. Conventional Petri nets

Petri nets are high-level graphs that are used in modeling simultaneous systems' activities. PN can store the analyzed results in the form of a matrix for future follow-up analysis, review and verification

of the features included in the PN [19].

2.2. Formal definition of PN

According to definitions, petri net is a normal method with five (P, T, I, O, M) in which [20]:
$P = \{P_1, P_2, \ldots, P_m\}$: is a finite set of places.
$T = \{T_1, T_2, \ldots, T_n\}$: is a finite set of transitions so that P∩T = ∅, T ≠ ∅
I = P × T → N: is an input function that defines direct transfers from P(places) to T (transitions).
O = T × P → N: is an output function that defines direct transfers from transitions to places.
M: is initial marking, marking assigning tokens to places.
Activity of a petri network begins with the activation of its transitions. The T transition is said to be able if any of the input places, P, in the transition has a minimum number of tokens equal to the transfer weight from T connected to P. To describe different states of systems in a petri net model, different numbers of tokens can be considered for places. Since the activation of a transition in the system is often associated with the change in the value of tokens in places, it can be said that Petri net models dynamic behavior of the systems with the activation of its transitions.

2.3. Colored Petri Nets

Colored Petri nets and their methods of analysis arose from *Aarhus University of Denmark*. The idea of colored Petri nets was first proposed by Kurt Jensen in his doctoral dissertation in 1980[17]. Then, CP-net group in the Department of Computer Science of Aarhus University developed its analysis methods and monitoring tools and then, Design / CPN software package was designed by students and researchers of this university to implement colored Petri nets [21].
Extension of colored Petri nets has been done with the goal of producing a modeling language. These system are called colored petri nets since they allow the use of discectomy that carry different amounts of data and are inseparable from each other.
Petri nets are, in fact, a graphical tool for formal description of dynamic systems with features such as: concurrency, mutual exclusion and conflict that are the obvious characteristic of distributed environments.
Colored petri nets are extended version of Petri nets. A colored Petri net model can be graphically displayed by a bipartite directed graph. In this model, places are shown with circles and transitions are shown with rectangles. Tokens are also shown with black discectomy in the places.

2.4. Formal definition of colored Petri nets

The formal definition of colored Petri nets with 9 sections is as follows [22]:

$$CPN = (\Sigma, P, T, A, N, C, G, E, I)$$

Where:
Σ: is a finite and non-empty set that is called a set of colors.
P: is a finite set of places.
T: is a finite set of transitions.
A: is a finite set of arcs, where:
N: is node function defined from P × T∪T × P.

$$P \cap T = P \cap A = T \cap A = \emptyset$$

C: is a color function defined from P to Σ.

G: is the guard function that is defined from T to terms such as:

$$\forall t \in T : [Type\,(G\,(t)) = B \ \wedge Type(Var(G\,(t)) \subseteq \Sigma]$$

Where, B is indicative of the Boolean type.
E: is an arc expression function that is defined from A to terms such as:

$$\forall a \in A : [Type\,(E\,(a)) = C\,(p)_{MS} \wedge Type(Var(E\,(a)) \subseteq \Sigma]$$

Where, p indicates the place of N (a).
I: is an initialization function that is defined from P to closed terms such as:

$$\forall p \in P : [Type\,(I\,(p)) = C(p)_{MS}]$$

2.5. Features of colored Petri network

Some of the features of colored Petri nets are as follows:

1. They have simple graphical display, so that they are understandable for people who are not familiar with the details of Petri nets.
2. They show the control and use of data together.
3. They are hierarchical. That is, a large colored Petri network can be made connecting smaller colored Petri nets to each other. This feature of colored Petri nets is similar to the role of subroutines, procedures and modules is programming.
4. They suggest interactive simulations, in a way that results are directly shown on the graph, enabling debugging when building models.
5. Computerized tools to drawing, simulation, and analysis are included. These tools are important for using colored Petri nets.
6. They are very general and can be used to describe a variety of informal systems such as describing the processes, formal systems such as communication protocols, software systems, and hardware systems.
7. They have primary components that are very small but powerful.
8. They provide a frank description of the mode and action of the system.
9. They accurately show the concept of concurrency.
10. According to the behavior of Petri nets in modeling and analyzing a dynamic system, the present study is an attempt to model customer trust in electronic business in the form off a system and assess and investigate customer behavior using Petri net.

3. Modeling decision making about trust in business using colored Petri net

As mentioned in the introduction, an electronic business process has multiple variables and factors that are mentioned below:
1. The BM (business model) : This variable represents a business model that is effective in electronic trust and is of different values according to the buyer or customer.
2. The individual variables: These variables reflect the individual characteristics affecting electronic business processes such as guild, gender, job, and living area.
3. The corporate or business variables: These variables indicate confidence features of companies in electronic business processes such as electronic trust certificates and warranties, and more.

Table 1: variables and their definition

	Variable	Description	Value range
1	BM (Business Models)	Buyer / Seller	Business, Whole Sales , Retailer - Industrial buyers - Citizen - Government - Employees
2	Individual variables	Age - Gender - Occupation - City Location	Male or female - Young, Middle-Aged, Old - Students, Self-employed, Employees , The provincial capital city ,Area
3	Business variables	Trust-seals , Trust marks	Electronic certificates, warranties, Insurance, Trust marks and seals
4	Infrastructure variables	Technologies rules , Individual rules, Trading rules	Website security measures - Rankings - Portals security and trust certificates

4. The infrastructure variables: These variables indicate the state of infrastructures of electronic business processes such as natural and legal rules and IT infrastructure.
These variables along with their value ranges are displayed in Table 1.
According to the existing variables of the system and different kinds of each variable, the colored petri net is used to model the system of customer trust in electronic business processes. In fact, the aim of this petri net is to model customers' decision making process about trusting or distrusting in electronic business processes in the form of colored Petri nets so that different factors and variables of decision making are taken into account and the main operating parameters of customers' trust are extracted. The overall process of the proposed system is, therefore, as Fig. 1.

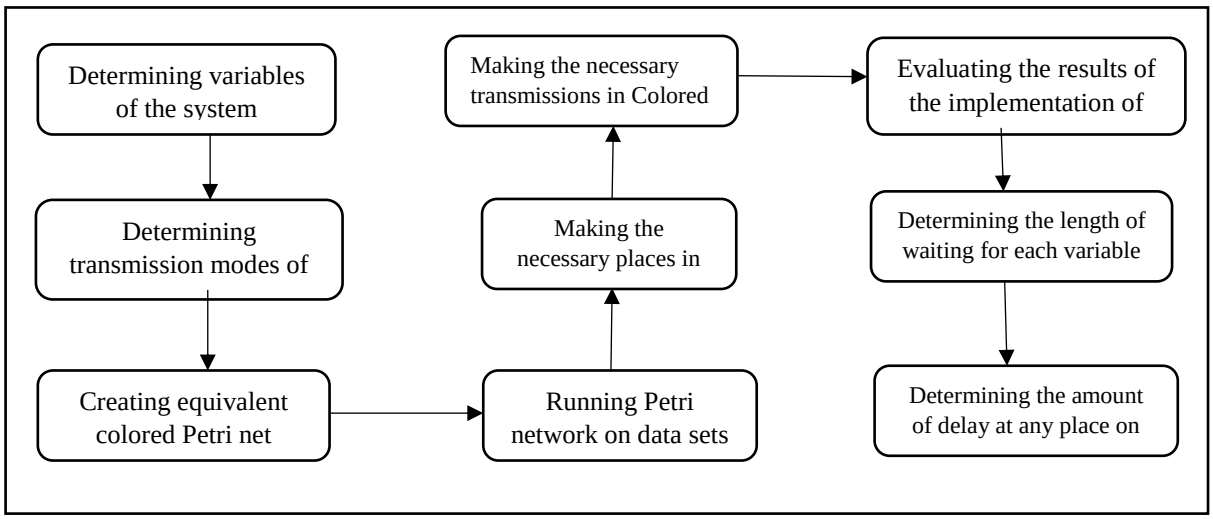

Figure 1: The overall process of the proposed model

According to the structure shown in Figure 1, the colored Petri net is designed to model the user's decisions about the level of trust in e-business model. For this purpose, the colored Petri net is formally defined as below:

$$CPN = (\Sigma, P, T, A, N, C, G, E, I)$$

Where:
P: represents the effective elements in deciding on the amount of trust in electronic business
T: represents the relationship between the elements of decision-making

I: Initialization of the decision variables
Σ: set of colors that is equal to the set of variables, i.e. one color is considered for any variable.
A: set of relationship between decision-making elements
N: set of decision-making elements
C: color function, i.e. one color is assigned to each decision-making element
G: Guard function that defines the activation condition of transmissions.
E: function to define the relationship between the decision-making elements
According to the abovementioned descriptions, places of the designed colored Petri net are as follows:

1. The place of decision making about business model variable
2. The place of decision making about individual variables
3. The place of decision making about corporate variables
4. The place of decision making about infrastructure variables

Having defined the places in the colored Petri net, their corresponding tokens and colors are defined. The list of tokens and colors in colored Petri net is as follows:

1. Tokens of the business model variables:
   It has the following fields that are shown in Table 2.

Table 2: List of fields related to business model variable

	Fields name	**Fields domain**	
1	Type	0: Buyer	1: Seller
2	Operation	0: Company 2: Retail Seller 4: Citizen 6: Employee	1: Wholesaler 3: Industrial Buyer 5: Government

2. Tokens of the individual variables:
   It has the following fields that are effective in deciding about trust in business model.

Table 3: List of fields related to individual variables

	Fields name	**Fields domain**	
1	Age	0: 15-25 2: 35-50	1: 25-35 3: higher than 50
2	Gender	0: Male	1: Female
3	Job	0: Free 2: Student	1: Employee 3: Businessman
4	City	0: Capital of country Province 2: Other	1: Center of

3. Tokens of the corporate variables:
   It has the following fields that are shown in table 4.
4. Tokens of the infrastructure variables:
   It has the following fields that are shown in table 5.

Table 4: List of fields related to corporate variables

	Fields name	Fields domain	
1	E-trust Certificate	0: False	1: True
2	Warranty	0: False	1: True
3	Insurance	0: False	1: True
4	Signs of trust	0: False	1: True

Table 5: List of fields related to infrastructure variables

	Fields Name	Fields domain	
1	Security Certificate	0: False	1: True
2	Site Rank	0: Low	1: Median 2: High

According to the above definitions, pseudo-code of the proposed algorithm for deciding about the degree of confidence in a business model is shown in figure 2.
As can be seen, the trend for making colored petri net from the abovementioned variables and conditions is run and then, the colored petri net is applied on users' data so as to evaluate and compare the compliance of users' decision making trend about trust in electronic business model with the proposed colored Petri net.
The colored petri net is made according to places, list of variables, list of field of each variable, and set of transmissions that are determined in the form of conditions.

Algorithm 1 Trust Decision Making Algoirthm

```
1: procedure INITIALIZE—CPN(P,T)        ▷ Initalize Colored Petri Net with
   P(Places) and T(Transactions)
2:     Set Places with defined variables
3:     Set Transitions with defined Constraints
4:     Define ColSet according to variables and constraints
5:     return CPN
6: end procedure
7: procedure TEST—CPN()                 ▷ Test created CPN on user's data
8:     for each consumer in data set do
9:         Create token for consumer
10:        Apply token to CPN
11:    end for
12:    Create Monitor on CPN
13:    Get token queue length of each place
14:    Excecute CPN
15:    Get statistics for each place according to CPN execution
16:    return MonitorResult
17: end procedure
```

Figure 2: pseudo-code of the proposed algorithm

4. Implementation of the model

In this part, the proposed model is implemented and compared with the results obtained from user behavior with regard to trust in electronic business model. Then, the obtained results are evaluated. Given the abovementioned descriptions, the list of places and transmissions of the designed model, along with their descriptions, is presented in Table 6 and Table 7. Figure 3 shows the implementation of this network.

The data set included the opinion of 3440 people about electronic business and its trust, which is obtained in the form of 6 questionnaires. Each questionnaire focuses on a key issue in the field of trust in electronic business model[23]. Data obtained from these questionnaires are used as the input of colored petri net. After running and simulating colored Petri network, the main decision factors and key points of the opinion of 3440 people are extracted and the conceptual model is presented.

Table 6: Places and their description

Place	Description
P1	Element of decision making about the value of electronic business model variable
P2	Element of decision making about individual features variable
P3	Element of decision making about corporate variables
P4	Element of decision making about infrastructure variable
P5	Approval of trust in the model
P6	Disapproval of trust in the model
Ps	Place to start model
Pf	Place to end model

Table 7: Transmissions and their description

Transmission	Description	Transmission	Description
T1	Type of seller or buyer	T8	Living area
T2	Type of company or real person	T9	Having an electronic certificate
T3	Type of wholesaler or retailer	T10	Having Warranties
T4	Type of citizen or employee of the government	T11	Having insurance
T5	Gender	T12	Type of trust symbol
T6	Job	T13	Web Security
T7	City	T14	Site ranking

The CPNTools is used to draw and simulate the model and evaluate its results [24].

After feeding the obtained data as the input of the colored petri net, the results of simulating petri net with the length of the line created for each place are shown in Table 8.

According to the results, the two factors of business model variable and corporate variable have the greatest effect on customers' trust in electronic business model. In fact, these two places have the greatest delay in the line related to customers' trust or mistrust.

Figure 4 shows the number of tokens of the length of line of each place for 3440 tokens.

Decision making model for customers' trust is shown in figure 5.

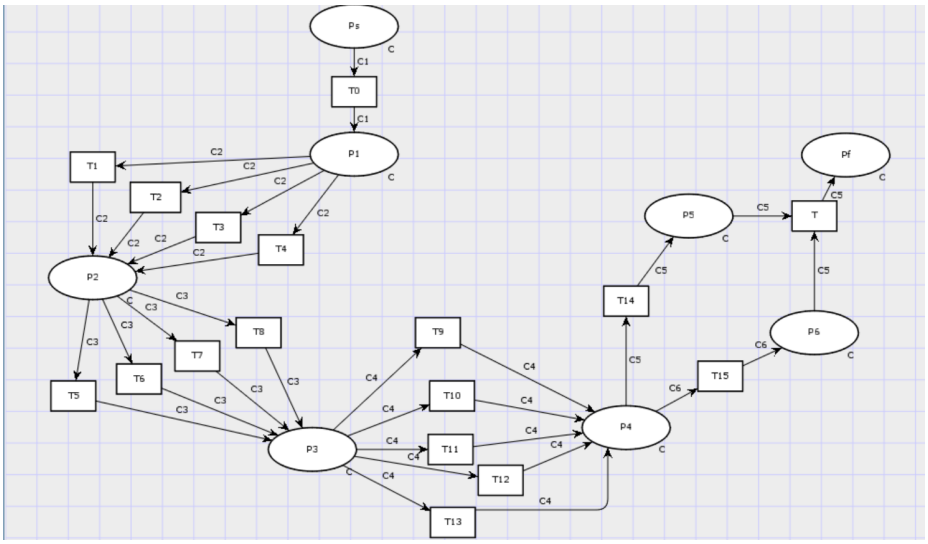

Figure 3: The designed petri net

Table 8: The effect of various variables on users' trust

Place	Description	The amount of effect (%)
P1	The element of decision making about the amount of electronic business model	41.23
P2	The element of decision making about the individual features variable	9.83
P3	The element of decision making about the corporate variable	42.16
P4	The element of decision making about the infrastructure variable	6.78

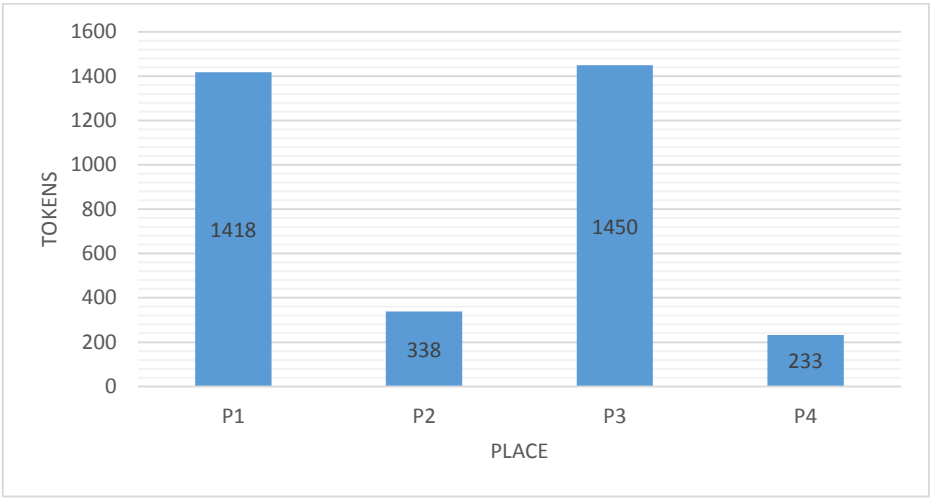

Figure 4: Line length for each place

5. Conclusion

In this paper, a method to evaluate the factors affecting trust in electronic business model using colored Petri nets was provided. The model was proposed with the goal of modeling users' decision

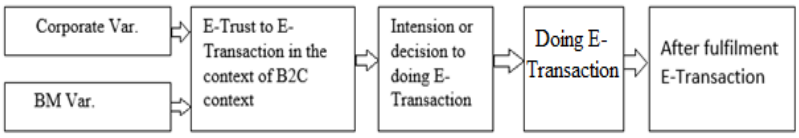

Figure 5: Conceptual model of making decisions about trust in business model in e-commerce

making system and determine more valuable variables. The results showed that in the population of 3440 people, variables related to electronic business model and corporate variables have the greatest effect on users' trust or mistrust. In other words, the main factors in deciding about trust or mistrust in electronic business model are the two abovementioned factors. Therefore, large volumes of customer trust can be attracted considering these two factors.

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